HOROLOGICAL
DIALOGUES.
In Three Parts £.32.94

SHEWING

The Nature, Use, and right Managing of

CLOCKS
AND
WATCHES:
WITH AN
APPENDIX

Containing Mr. *OUGHTRED's* Method for Calculating of Numbers.

The whole being a work very necessary for all that make use of these kind of Movements.

By *J. S.* Clock-maker.

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TO THE

READER.

CLocks being things in themſelves ſo uſeful and excellent, that no production of Art whatſoever doth ſurpaſs them (eſpecially thoſe that are truly and well made) yet are extraordinarily ſubject to give

dissatisfaction to those that own them, which happeneth from two Causes; the one from the Workman's unskilfulness and unfaithfulness in making them, and the other is from the Owner's unskilfulness in keeping and managing them. To remove the latter of these Causes hath engaged me to endeavour (in the following Tract) to reveal (to those that are ignorant) some of those secrets that are necessary to be known by those that would rightly ma-

manage them: in doing which, I have been as plain as possible, considering the brevity of it, and I doubt not but it will give sufficient light to any understanding man whatsoever, and though it come forth into the world but in a plain Country dress, yet I can assure you it hath a good design, and will deliver those things that are of use and profit to all that have occasion to make use of it, from whom I hope to gain a

friendly acceptance, which if I find sufficient for further encouragement, then this shall not be the last of my endeavours to serve you,

J. S.

A

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HORO-

HOROLOGICAL DIALOGUES:

The First Part.

DIALOGUE I.

The definition of Clocks: the reason of their Several distinctions, with an account of the most common kinds now in use.

Chi BEing desirous to furnish my self with sufficient knowledg in things of either use or profit to man, I considered the safest Inquiry would be of persons whose knowledge was compleat in those things which I purposed to inquire after, to which end, being desirous, among other things, to understand as much of the nature, use, and right managing of Clocks as was possible for one that was not a work-

man, in that kind, I thought it best to apply my self to you; who, being an able Artist in that profession, may therefore be the more likely to satisfie my curiosity in this particular, provided you are as willing, as God and education hath made you able.

Articus, Sir, the most noble and ingenious productions of Nature and Art (I have observed) are alwaies of more value and esteem among men, when their vertues and qualities are throughly understood and truly discovered, then they are so long as the same lyeth hidden and concealed; which Consideration is to me a sufficient motive to ingage my self to serve you in this your request as far as my weak capacity will permit me, especially in those things that are absolutely necessary to be known by those that intend to make use of any sort of Clocks whatsoever, hoping thereby to whet the edge of your esteem of so ingenious an art. Propound therefore those things you would be satisfied in and I shall indeavour to give you an answer.

Chir. In the first place let me understand

ſtand what you define a Clock to be.

Art. A Clock is a certain inſtrument invented and contrived, to give the true hour, either of the day or night, (by the Circuler moving or certain wheels and pinions artificially diſpoſed within the Body of the Inſtrument) without the help of either Sun, Moon, or Stars, or any other of thoſe elemental aſſiſtances, which the Antients did in former ages make uſe of to divide their time by.

Chiv. Are Clocks more uſeful for finding the hour, then any other Inſtrument heretofore made uſe of.

Art. Clocks in that perfection, in which this age enjoys them, excel all other inſtruments in its officiouſneſs at all times, and in all places, as well in the nights, as in the day, as well in cloudy skies as in clear weather, as well in cloſe roomes as in the open *Air*, which no other Horological Inſtrument beſides this is able to perform, many being defective, where the Sun giveth a perpendicular ſhaddow, and in cloudy weather, in cloſe roomes, and in the night, moſt are likewiſe of no

use; whereas on the contrary, let the time be when it will, the weather what it will, or the place where it will, all is one to a Clock, it shall give the time as certain in one as in another, provided it be in perfect order, and well adjusted.

Chiv. From whence are all those various names, and denominations of Clocks derived.

Art. They are derived, first, from that which is the principal and prime cause of their motion, being either weight or Spring.

Secondly, from that, which retards and regulates the violent motion of the wheels, being either, ballance or pendulum.

Thirdly, from the time they continue in motion at once winding up; some going 16 houres, some 30 hours, some 8 days, some 5 weeks, some 3 moneths, some 6 moneths, and some a year.

Fourthly, from the offices which they perform, some giving the hour onely by the pointing of the needle, others expres the

the ſame by the ſound of a bell. Some ſtrike quarters, ſome repeat the hour, and ſome chime tunes.

So that from the permiſcuous intermixtures, of theſe four foregoing heads, are derived all theſe various and manifold diſtinctions, and denominations, under which they have been exhibited unto the world, of which be pleaſed in the following Scheam to take a view of.

A Scheam of the names and titles of Clocks.

1. Spring / Weight — Ballance / Pendulum — Watches
2. Spring / Weight — Ballance / Pendulum — Watch and Larums
3. Spring / Weight — Ballance / Pendulum — Clocks

4. Spring, Weight, Ballance, Pendulum, Quarter Clocks

5. Spring, Weight, Ballance, Pendulum, Repeating Clocks

6. Spring, Weight, Ballance, Pendulum, Quarter Repeating Clocks

7. Spring, Weight, Ballance, Pendulum, Chime Clocks

8. Spring, Weight, Ballance, Pendulum, Quarter chime Clocks

9. Spring, Weight, Ballance, Pendulum, Repeating Chime Clocks

10. Spring, Weight, Ballance, Pendulum, Quart. Repeating Ch. Clock.

To

To all which, if you adde that ſpace of time, they continue in motion at once winding up, you have the names of 40. Of the chief and moſt common kinds now in uſe among us, the reaſon why I have omited the mentioning of ſome which have been formerly, and are ſtill made uſe of, which differ from theſe aforementioned both in name and nature, is, becauſe they are but the productions of meer whimſeys, not at all anſwering the expectations of thoſe that compoſed them, or have made uſe of them, upon which account tis Judged, their memory may periſh with their diſſolution, for want of the ſame kind to ſucceed them, when they are decayed, and therefore ſince there is uo likelyhood, of their being much or long in uſe, I have forborn to ſpeak any thing of them.

DIALOGUE II.

The manner how all Clocks naturally perform their Offices.

Chi. BY what you have delivered in the foregoing discourse, among other particulars therein mentioned, I find that Clocks perform their offices by wheel-work, but in what manner they move, or act, I am still ignorant, and therefore would be gladly informed somewhat thereof.

Art. All Clocks, consist of one or more parts, or sets of wheels and pinions, (a set consisting commonly, of so many wheels and pinions, as are moved by the draught, or poysure, of one Weight or Spring.) Of those that consist but of one part, or set of wheels, are pocket Watches, and all other moments of what form or fashion soever, that strike not on a Bell; these having their

their Wheels and pinions differently indented in their perypheris (according to the judgment of him that compoſeth it.) do by vertue received from either Weights or Springs, ſucceſſively move each other in a circular manner, having the rapidity of their motion, ſo retarded and regulated, by either Ballance or Pendulum, that the needle, who alſo is moved with the reſt of the work performs its revolution in twelve hours (or parts of time) thereby dividing at twice going round, the day and night into twenty four equal parts, which are commonly expreſſed by the pointing of the needle to a Circle equally divided into twelve parts, which are called hours, whereunto are annexed figures, ſufficient to diſtinguiſh the ſucceſſive diviſions thereof, ſo that by the pointing of the needle, to any of thoſe diviſions, or their intermediate parts, you have the true hour given, whenſoever you make inſpection thereon.

Thoſe that conſiſt of more ſets of Wheels then one, are all thoſe move-

ments

ments that ſtrike on bells, of which the Clock is one, being compoſed of two parts, a watch part, and a ſtriking part, the watch being the ſame as was ſpoken of before, I ſhall paſs here: as for the ſtrikeing part, it is that whereby the Clock is made by art to give intelligence of its diviſions of time, by ſtrikeing ſeveral ſucceſſive blows on a bell, ſufficient to expreſs the number of hours, that have paſſed, ſince the laſt meridian altitude, or depreſſion of the Sun, which is thus performed.

The wheels contained in the ſtriking part being at the end of every hour unlocked by certain detents for that purpoſe appointed, continue the rapidity of their motion which is the cauſe of the hammers ſtriking until the locking detent, which is appointed to ſtop them, fall into the next ſucceſſive notch of a moving wheel, called the count wheel, for that purpoſe indented concentrick at ſeverall diſtances according to the number of ſtrokes at each time to be ſtrucken.

Chi. By the deſcription here given I am

am much ſatisfied, concerning the natural motion of wheels in a Clock, but if you have any thing further to declare I ſhall be very deſirous to hear it.

Art. There is nothing more to be ſpoken concerning this matter that will be worthy your attention; what hath already been delivered is ſufficient, for there in not any part of Clock work whatſoever which moveth not according to the order here before deſcribed, ſo that if they contain quarter repeating or Chime parts, yet their order in motion is the ſame in effect with what hath been before delivered.

DIALOGUE III.

Wherein the goodneſs and excellency of a Clock chiefly conſiſteth.

Chi. That little knowledg which I have gained by our former diſcourſes makes me, ſtill the more deſirous to be informed further concerning theſe mo-

motions of returns, whereof in the next place I shall desire some account wherein the chief goodness of a Clock consists that I may (at least in discourse) be able to difference those that are good from them that are bad.

Art. The chief goodness of a Clock consists chiefly in these two things; first in its dureableness; secondly in its officiousness; and that it may be either durable or officious several things are required.

First for its dureableness the first thing required is that the chief parts of which it is composed, be of metal answerable in hardness to the extremity of its performance.

And Secondly that true proportion and uniforme figure be observed in all its parts.

Chi. You speak well in my opinion as to the first of these, for I am certainly perswaded that those german movements and others, formerly made, were far more lasting and dureable then those which these latter ages have produced for certainly

tainly, them whoſe wheels and other parts were made of the pureſt ſteel muſt needs outlaſt thoſe who are made in braſs, it being a much ſofter metal and ſo conſequently more ſubject to decay.

Art. Your not right underſtanding the firſt thing required in my firſt propoſition hath been the cauſe of this your great miſtake. I confeſs indeed that ſome part of thoſe antient movements you ſpeak of do in our days ſeem many of them to be very little worn: Yet I will prove to you by plain and evident reaſons, that thoſe Clocks and Watches, which we make now a dayes (though the wheels and other parts are compoſed of braſs the ſofter metal) ſhall in the general out laſt all others whatſoever, provided it be truly and religiouſly wrought: to prove which conſider firſt that the ſervice of all pinions are in ſuch proportion to the wheels that moveth them (or are moved by them) as their numbers are one to another ſo that if a wheel contain ſixty teeth and the

pini-

pinion which it moveth about contain but ſix, the ſervice of this pinion muſt needs be ten times as much as the ſervice of that wheel, becauſe it maketh ten revolutions to the wheeles one, and ſo by conſequence every tooth (or leaf) of that pinion muſt be worn ten times as much as every tooth in that wheel, to make therefore theſe wheels and pinions to wear alike, and continue the one as long as the other, tis requiſite that the ſubſtance of the pinion ſhould be ſo many degrees more hard and durable (as its proportion of wearing is) then the ſubſtance of the wheel which moveth it, by which means they will wear better and continue longer without reparation then otherwiſe tis poſſible for them to do; for if you obſerve thoſe german movements you ſpeak of (whoſe wheels and pinions and other parts are all of ſteel) you ſhall find the pinions irrepairably decaied, when the wheels are never the worſe, for ſince that almoſt all the wearing to which thoſe parts are liable be laid on the pinions

nions, we may reaſonably conclude that they are ſooner worn out (by juſt halfe the time) then they otherwiſe would have been, if the wheel had been made of ſuch a metal, whoſe proportion of hardneſs or ſofeneſs would have admitted an equal ſhare of wearing with it, which ill conveniencies are all avoyded by that method of working now a days uſed in framing of theſe movements: therefore in this ſort of work take this for a general rule (where there is no exception): that what proportion of wearing one part beareth unto another ſuch a proportion of hardneſs ſhould the metal of the one have above the other to make them wear equal, and Continue long in that placide eſtate of motion which is requiſite in things of this nature.

Ch: I am now in part convinced of my error, but yet, I think, your general rule holds not good in all parts of a Clock, for then how comes it to paſs that in Clocks, you make their pevets which are of ſteel, to move in frames of braſs this according to your general rule cannot

not wear equally, because they are substances of uncqual hardneſs, yet perform both the ſame taske; whence we may conclude that the more ſoft muſt needs be more ſenſiable of the wearing then that which is more hard, therfore how can your method of working, be good in theſe parts.

Art. The rule and method holds good ſtill (with our exception) for though it be an ill convenience in other parts, yet in pevets and their receptacles it is not ſo, for reaſon requires if 'twear poſſible, that all the wearing to which thoſe parts are ſubject ſhould be in the pevet holes, and not in the pevets themſelves; for when pevets, are worn and decayed theres no repairing them without new pinions (which is exceeding chargeable) whereas pevet-holes are more eaſily reduced and with far ſmaller coſt, thus of two evils we have choſen the leaſt.

Chi. Why, are true proportion and uniform figure required to make the movement of a Clock more laſting and durable.

Art.

Art. True proportion and uniform figure are required, because without it, movements of this Nature cannot perform, and we count a Clock to be worn or (which is all one) to be of no value, when he ceaseth to performthat office for which he is designed: if therefore the teeth of the pinions are not proportional to the teeth of the wheels, or the teeth of both to themselves, if the pevers are too big or too little, if the wheels are too large, or the generality of the work too heavy and cumbersom, 'tis certain this Clock is not of the number of those that are accounted the best.

Chi. What is required in its officiousness to make it good or excellent?

Art. In its officiousness two things are required, first continuance in motion; secondly regularity in the same: as to the first of these 'tis certain, that these Clocks, that have true proportion in their parts and uniformity of figure also, must needs be a Clock of continuance in motion, according to the best kind? provided it be well defended, by case or o-

therwise, from air and dust; the one being subject to rust the steel work, which may happen to put a stop to its motion, and the other, by clogging the teeth, and choaking the pevets, will be apt to produce the same effect.

As to their regularity I shall say only thus much, that those Clocks, who have their motion regulated by a Pendulum, are more excellent then those who are regulated by a Ballance, and those, that are regulated by a long Pendulum, are far more excellent than those that are regulated by a short one; to all which I shall add this one general rule, that those Clocks are to be accounted best, that perform most with least work.

DIALOGUE

DIALOGUE IV.

Of the ſeveral concluſions that have been, are, and may be wrought by the motion of Clockwork.

Chi. Is it poſſible by the moving of Clockwork to repreſent or work any other motion or concluſion then that of the hour.

Art. Of thoſe ſeveral motions and concluſions that may be wrought by Clock-work I will give you an account as far as my knowledge or inquiry will permit me: the firſt thing I ſhall deliver as poſſible to be effected by their motion, is that firſt they may be made to ſhow the month of the year, the days of the moneth, the the hours of the day, the minutes of an hour, and the ſecants of a minute.

2. They may (beſides the hour

in any particuler place) be made to ſhew the hour in any place of the known World; ſo that, by inſpection thereon, you may have readily given you the hour at that time, as it is naturally, in any particuler known Region, Kingdome, or Principal City in the Univerſe.

3. They may be made to ſhew the Suns place in the twelve ſigns of the *Zodiack*, his declination from the equinoctial, his right and oblick aſcention, his amplitude, riſing and ſetting, length of the day and night, with the beginning and ending of twilight, throughout the whole year.

4. They may ſhew the moons age, time of her new, full, and quarters, her riſing, and ſetting, and ſouthing, her time of ſhining, and motion through the twelve ſigns of the *Zodiack*.

5. They may ſhew the riſing, ſetting, and ſouthing of any fixed Stars.

6. They may ſhew the time of the

tide

tide or full ſea in any Port or Harbour whatſoever.

7. Beſides the hour, they have been made to ſtrike the minutes, and quarters, repeat the hour, Chime Tunes on Bells, play on the Organ, Harpſecal, or Virginal.

8. Beſides the lively and delightful motion that hath thereby been given to Artificial Creatures, ſuch as dogs, mice, flyes, fouls of the air, and figures of men, women, and the like.

Beſides all which it hath been reported, by one of the Ancients, that a Prince in his time was (by a German) preſented with a Clock, which, beſides the hower, did alſo repreſent the moving of the ſeven planets in their direct retrograde and ſtationary motions: which if true was a work worthy admiration.

DIALOGUE V.

Some few rules how a man may furnish himself with either Clocks or Watches that are really good and substantial.

Chi. The time that hath been spent in giving and receiving these first Rudiments of knowledge in this kind, hath in my opinion been something larger then necessity seems to require, Considering that what hath been delivered has rather been to satisfie an inquisitive curiosity then for any great use or profit contained therein; therefore since I have gained sufficient knowledge in these lesser matters let us proceed to those of more importance, and herein I shall desire you to give some few directions what course is safest to be taken in furnishing my self with a good Clock.

Art. If you intend to furnish your self with Clocks that are really good and

and ſubſtantial you muſt obſerve theſe three rules.

Firſt that you apply your ſelf to a work-man who is of reputed ability: he that is maſter of his Art is the only perſon in nature from whom you can in reaſon expect either Clocks or any other movements whatſoever that are perfect, ſound, and good work.

Chi. You ſay well, but I have obſerved, that fame or repute is many times the product of ſome particular affections, and too often is conferred one thoſe that leaſt deſerve it, therefore that I may not be deceived in the repute of a work-mans ability what rule ſhall I walk by.

Art. Not by the populer applauſe of ligh tand vain perſons : but by the commendation of the more ſober and ſoled ſort of men.

Not by the fame of unexperienced relations; as by the teſtimony of his own labours.

Not by his fair and beautiful ex-

preſſions: but by his plain downright and ſolid reaſons.

So that if his reputation be derived from gravity: if his work have performed according to the expectaion of thoſe that have uſed it: and he be able to give a reaſon of any thing that falls in his buſineſs, you may in a large manner put confidence in his ability.

Chi. But ſome Clocks that have been made by perſons of good repute have failed exceedingly in their performance (as might be inſtanced in ſeveral) though they indeed at laſt were perfected, but it was with a great deal of trouble.

Art. This might be for ſeveral other reaſons, and not from any deficience in the work-man; as firſt, it might be ſome accidental injury in the conveiance from one place to another, as ſometimes happens by jogs or ſquats which looſen either pins, wedges or ſcrews which many waies may impede its motion.

Secondly

Secondly there may be some small matter not freed in the finishing, which many times escapes the care of the best work-man, and may happen not to discover it self till sold, all which may occasion some defect in its performance, and this defect may occasion some trouble to find its cause, for if the cause be once found 'tis then easily cured, only the hardest thing is to find the cause, but however the work of a reputed Artist, may thus fail by chance, yet this can be no cause for you to distrust his ability, for the best work-man being but a man may be subject to error, and if in the general he prove a sound work-man once failing is not to be taken notice of.

Chi. What is the second rule I am to take notice of.

Art. My second rule is that your work-man be not onely a person of reputed ability, but also of known integrity, for though a sound work-man be able to furnish you with good

work

work; yet the ſafeſt dealing will be with him that is both able and honeſt, an able work-man can furniſh you with good work, if he will, and an honeſt man will furniſh you with good work, therefore he that is both able and honeſt, both can and will furniſh you with good work if you obſerve.

My third rule, that you reſolve to give a price valuable to the work you purchaſe, there is a ſaying which among Clock-makers is aparently true, that he that ſels a Clock for a ſmall price cheats either himſelf or his cuſtomer, for if he ſels good work at a low rate, he cheats himſelf; but if he ſels bad work at a low value then he cheats his Cuſtomer, who expects (commonly) that it ſhould be good though he buy it at an inconſiderable price; therefore if you are minded to furniſh your ſelf with a good Clock be as willing to give a good price as you are to have good work.

Chi. But ſuppoſe that I ſhould apply my ſelf to ſuch a perſon you ſpeak of

of that is both of repute, ability, and known integrity, and one that for a good price hath made good work; yet, I fear, I may here be cheated, for when I come into his shop with a resolution to give a good price for that which is good; I may have chance to pitch upon one that is not of his own make, for I have observed that they all keep servants, who seldome prove so careful as they ought, especially if their masters eye is not alwaies one them.

Art. He that is honest and faithful in his dealing will certainly inform you of the difference if he finds you thus resolved valuably to purchase the best, but however considering temptations your best way not to be deceived is to bespeak it afore hand agreeing with the work-man both for price, time of going, performance, and shape; this is the surest way, for a work man that knoweth his price knows also what time he can afford to spend in makeing it good.

Chi. But is it not possible for a man that

that is not an Artiſt, to be capable of knowing good work.

Art. Tis very hard, yet to ſatisfie your deſire I will give you two or three rules that may poſſibly ſtand you in ſome ſtead.

Firſt be ſatisfied if poſſibly, whether the teeth of the wheels be cut down by an ingine or not, for there is no man can cut them down by hand ſo true and equal as an ingine doth,

Secondly let the vibrative traine of the Pendulum or Ballance be brisk and lively, continuing its motion ſome time after the tooth hath ingaged with its pallets, and not check or return ſo ſoon as they have beaten thereon, tis alwaies commendable to to ſee Clock or Watch-work, move thus brisk and lively, and a great ſign it hath paſſed a good hand.

Thirdly, Obſerve whether every particular part of it be true and ſquare whether it be clean, ſmooth, and well poliſhed. whether the needle or hand be true filed, and of a neat order whe-

ther

ther the hammer ſtrike one the Bell ſo true as may cauſe it to give its ſound clear and ful without intermixture of harſhneſs and Jurgelling, and whether the work be generally in all its actions lively, brisk and pleaſant, if you find all theſe in a Clock you may conclude it was made by the hand of a good work-man, and conſequently that it is good work, which is alwaies beſt cheap though it coſt dear.

DIALOGUE VI.

The way and manner of packing up and conveying all manner of Clocks from one place to another, as occaſion ſhall require, as alſo rules to be obſerved in ſetting them up and fixing them in the places they are deſigned to ſtand in.

Ch. In removing of Clocks, as occaſion may happen, how ſhall I do it without prejudice.

Art.

Art. If you have occasion to convey any Clock of worth from one place to another you must do thus: provide for it a coffin or box of deal boards or other wood, let it be strong enough, provided it be not too heavy and cumbersome, let this box be of bigness sufficient to contain your Clock (with case or without) having besides space enough left both at bottom, top, and sides, to thrust in Straw, or Hay, (or any other matter that is soft and yeilding) in such quantity as may be sufficient to keep it free from the sides of the coffin: when you have thus provided your coffin or box let your Clock (whether in case or otherwise) be carefully wraped up in paper or Cloths (according to its bigness) to keep it from dust and fowlness having before fastened every thing in it that may receive prejudice by being loose as the pendent of a Clock, or a Clock in the case, or the like: when you have thus wraped it up safe, then in the bottom of the coffin or box, place a

lay

lay of Straw, upon which lay in your Clock, then with Straw or Hay let it be so close packed up both at bottom, top, and sides, as the Clock may not be able to stir therein (alwaies observe ing to be careful of glases or ornaments that they be free from compression) then fasten on the cover by nailing or Cording it; so is your Clock sufficiently packed up, and may he safely conveyed to any place whatsoever without harm or prejudice.

Chi. When I have thus safely conveyed it to any place, how then shall I deal with it to set it up rightly,

Art. When you have gotten it home, the first thing you have to do is gently to open the box, pull out the packing and take out the Clock then take off that with which it is covered, loosen those things that are fastened in it, so is it ready to set up for going.

If it be a Ballance Clock of the ordinary sort, the trouble is not much but onely to drive in an hook into either post

poſt or brickwork, ſo that it may be faſt, indriving of which obſerve not to drive it too far at firſt, till you have tried with your Clock whether it hang up right from the wall, if it be not enough you may drive it further till you find it enough, then hang thereon your Clock (by that proviſion which is made in it) as upright as your eye can Judge it will do well enough for theſe ſorts; when you have hung it up, then hang on the weights, where note that they are commonly marked, (or ſhould be) the one with a W. the other with an S. let that weight that is marked with the S. be hung on that line which is next the wall, and let that which is marked with the W. be hung on the cut moſt line, ſometimes there are quarter Clocks which have more weights then two, in this caſe, it is convenient to faſten to the lines pieces of paper marked with the ſame marke that the weight is to be hung on it.

Chi. In what manner ſhall I ſet up a pendulum Clock.

Ari.

Art. If your pendulum Clock be of the ordinary ſort the trouble and manner of hanging it up is the ſame with the Ballance Clock, *viz.* to drive an hook for it to hang on, which when you have donē you may hang on the weight without any difficulty, becauſe they commonly go but with one, which you cannot well miſs in hanging; the greateſt difficulty is to hang thoſe Clocks upright, for if they are not placed exact, they will not go, the onely rule to know when a Pendulum Clock hangs exactly is by the beating of the pendulum, for if it ſtrike not equal, that is, if there be longer time betweēn beating of one blow, then there is between the beating of another, be ſure it ſtands not upright; to remedy which you muſt elevate either one ſide of the Clock or the other, till you find it to vibrate equally, in doing of which obſerve, that if, when you have ēlevated one ſide of your Clock, it beats more unequal than before, then be ſure you have e-

levated the wrong side, therefore proceed to the elevation of the other, till you find it to vibrate equally.

Chi. What rules must be observed in setting up the long-swing weekly Pendulums, or others of the like nature.

Art. In setting up long-swing Pendulums, after you have taken them from the coffin, open it, and make free all things that are fastened, as before was taught, then in the room it is designed to stand in, seek for some post if possible near the place you desire it should stand at, to which prosser the Clock and case together as it is, which done fasten the back part of the Case with a nail or screw to the post, then hang on the weight according to the marks by the work-man given, and set the Pendulum on vibrating, and according to the beating of it you will understand which way to elevate or depress the same to make it beat equal and swing clear of the case: then when you have found

found it to ſtand in its true poſition, faſten it with another nail or two, that it may ſtand firm and not ſhake: the ſame rule that is given for this ſerves for all other trunck-caſes whatſoever.

Chi. What rules have you for placing Spring (or table Clock.)

The difficulty of placing theſe is not great, for after you have looſed whatſoever was faſtened for conveniency of carriage, you have no more to do but to ſet it on a Table, Cabinet, or other place convenient for it to ſtand on (which moſt commonly ſtand up right) but after you have placed your Clock thereon, if it be a pendulum and you find it not to beat right, you may remedy it by putting under that part of the Table, Cabinet, *&c.* that is too low, a ſmal wedg, till you find it to ſtand right and vibrate equal.

HOROLOGICAL DIALOGUES.

The Second Part.

DIALOGUE I.

Of pocket Watches; Watch and Larrums; and Clocks; their use right managing and true adjusting.

Chi. What is the chief use of watches, watch and larrums, and Clocks.

Art. The chief use of the pocket watch is, with the pointing of the needle to the circle of hours, to give the true hour of the day or night; the watch and Larrum not only giveth the hour by the pointing of the needle, but is also by Art contrived to ring on a bell, at any certain hour you shall appoint, being chief-

ly designed to awaken people at any certain hour of the night, according as they shall have occasion to raise themselves; the Clock not onely giveth the hour by the direction of the hand to the Dial figures, but doth also (as I have said before) give intelligence of its divisions of time, by the sound of a Bell, strikeing thereon so many stroaks as are sufficient to give an account of the hour it expresseth.

Chi. What is to be learnt as necessary to the right managing of these movements.

Art. In the managing of the pocket watch, you must first wind it up rightly; which you must do by turning the Key of it contrary to the motion of the Sun, or from your right hand upwards (or from you) towards your self, which ought also to be done not too hastily, least you force the stop, and break the string; and commonly those, that strive to wind them up the contrary way, bow either the teeth, or break the pinions;

like

like unto this is the manner of winding up either Watch and Larrum, or Clock; but the Watch and Larrum, being appointed to ring at any certain hour must thus be set to perform its task; they have commonly two circles whereon, are ingraven the twelve hours, one in large or capital figures, the other in small figures, which are appointed to set the Larrum by, within which is a small hand; now, what hour soever you would have your Larrums to ring at, to that figure, in the innermost circle, set your Larrum hand; as if you would have it ring at five in the Morning, then set the little hand within the small circle (which I call the Larrum hand) to the figure of five contained in that small circle; then winde up the Larrum, and the next morning you willl see the effects.

Chi. How is the Clock to be ordered.

Art. The Clock, in the winding up of its several parts, must be ordered as the watch, but in other respects

requireth a different ordering, for if the hand be not at the true hour, it muſt be ſet thereunto gradually from one hour to an other, letting the Clock ſtrike out betwixt each hour, for if you ſhould turn the hand forward haſtily two or three figures together, you will indanger the breaking of the detents, if they ſhould happen to riſe againſt the warning pin.

If the hand and the ſtriking are not together, that is, if it ſtrikes more or leſs then the figure, which the hand points at, you muſt bring them together thus, by lifting up continually the locking detent, ſo often as occaſion ſerves, till by ſtriking of it round you bring it to ſtrike ſo many as the figure ſignifies, to which the needle points.

Chi. How are theſe movements to be adjuſted and brought truly to the hour.

Art In adjuſting of theſe movements what is neceſſary in one, is ſufficient for all, being all rectified in their going

ing

ing by the ſame rule, if therefore a Watch go too faſt, the ſpring muſt be let down to make it go ſlower, if it go too ſlow the ſpring muſt be taken up to make it go faſter.

Chi. How ſhall this be performed.

Art. By turning the endleſs ſcrew, that the figures moved by it may increaſe or diminiſh: as if you would make it go faſter, turn it that the figures may paſs from 1 to 2 and from 2 to 3 *&c.* but if you would have it go ſlower turn them from 4 to 3 and from 3 to 2 *&c.* and thus you may bring the moſt common pocket work to the true time or motion in which it ſhould move.

Chi. It hath been obſerved, that ſome Watches go too ſlow when they are firſt wound up, and too faſt when they are almoſt down, and ſome go too faſt, when they are firſt wound up, and too ſlow when they are almoſt down; which all the leting down or taking up of the Spring would not remedy.

Art. This proceeds from a fuzey not truly adjusted to the draught of the Spring, and must be rectified by a work-man, being one of the hardest knacks that belong to a Watch-maker to perform exactly.

DIALOGUE II.

Of ordinary domestick Ballance Watches, Watch and Larrums, and Clocks, their use, right manageing, and true adjusting.

Ci. what is the chief use of these movements.

Art. The use of these is the same with those in the former discourse, (onely their use is more manual then theirs, and the use of these more domestick then they) but their manner of ordering differ something, for these are drawn up by the lines themselves, and the Larrum is set by turning the

Cir-

Circle of ſmall figures, till the figure, repreſenting the hour you would have it ring at, be ſet under the back end of the hand; as if you would have it ring at 4 of the Clock in the morning, turn the Circle about till you ſet the figure of 4 thereon juſt under the back (or ſhorter end of the hand,) ſo ſhall you have its deſired effects, if you draw the weight of it up.

For the ordering the Clock, in reference to the making it ſtrike true with the hand, tis the ſame before delivered concerning the pocket Clock; whether I refer you.

Chi. When theſe movements go too faſt or too ſlow, how ſhall they be rectified and adjuſted.

Art. Theſe movements going with weights muſt be brought to keep true time by adding to or diminiſhing from them: if they go too ſlow you muſt add thin ſhifts of lead to the weights to make it go faſter, but if it go too faſt then you muſt diminiſh the weight to make it go ſlower, ſo that, whenſo-

ever

ever you find it either to gain or loose, you must thus, by adding or diminishing, rectifie its motion: note that these Ballance movements are exceedingly subject to be altered by the change of weather, and therefore are most commonly very troublsome to keep to a true time, except they are your pocket watches, which by reason of their being alwaies kept near the heat of a mans body, are less sensible of the alteration of Air, and so less subject to be varied by it.

DIALOGVE III.

Of Pendulum Clocks, their use, right managing, and true adjusting.

Chi. What rules give you for the right ordering of the pendulum Clock.

Art. The Pendulum Clock being the most perfect, we shall deliver the full

full order and manner of true keeping it; first, after you have fixed it to the place where it is to stand, you must give motion to the Pendulum by a touch of your finger, for it will not move of it self, but must be set one vibrating by manual operation, when the Pendulum is in motion it must not be touch't, for that will settle it still, and keep it from going.

It must be pulled up by the hindmost line of the counter weight.

It must by no means be Jogged out of its place, or beaten a wrye, for that will put a stop to the motion.

Chi. How must it be ordered as to its striking?

Art. The same way that the other Clocks were by continual lifting up of the locking detent, till you have brought the striking and the hour together, did it either strike too much or too little; here take notice that the locking detent is on the right side of the Clock, if it go with one

weight, but if it go with two weights then the locking detent is commonly on the left side of it, as it is in ordinary Ballance Clocks; for the Justening of the Pendulum, it is done by altering the Radius thereof, either longer or shorter, as occasion serveth, so that if a *Pendulum* go too slow you must, by screwing the bob from you, shorten its Radius, which makes it vibrate oftner and go faster, but if it goes too fast then you must screw the bob lower, by turning the bob towards you, which makes its Radius longer, and by consequence obligeth it to go slower.

Chi. When a *Pendulum* is once rectified will it not alter like the Ballance Clock?

Art. The short *Pendulum* is subject to some alteration, but not so often nor Considerable as the Ballance: upon extream foulness they have been observed to go too fast (contrary to the custome of Ballance work who is then subject to go too slow) the reason of

of its thus going too fast when foul, is the choaking of the pevets with dust, which hinder the motion of the Pendulum, and restraineth it from fetching its wonted compass, so that the Arch of its recursion being shortened it must needs pass it in lesser time, and so by consequence gain as to its wonted course; of which more may be understood when the Pendulum is treated of.

Chi. Have you nothing more to deliver concerning Pendulums?

Art. Nothing more concerning these ordinary ones, I confess, somthing more might be delivered concerning the more richer kinds, but it being so hard to teach by precept without example, that *I* shall forbear. However what hath before been delivered is of good use in their managment, as to the matter of adjusting and setting them.

Chi. Is the long pendulum subject to variation as the short one is?

Art. No; being once brought to a

true

true time it alwaies keeps it, for it moveth in so small an arch, that tis unpossible for it to move less without standing, and more it cannot being impeded by the work; so that being confined that it cannot remove more or less from its center of gravity, it must needs keep a certain motion as to it self.

Chi. But tis observed that they vary many times from the Sun, how can this be but from the Pendulum?

Art. I confess there is some small difference many times between them and the sun, but this is not from the Pemdulum but from other causes which shall be treated of when I shall discourse the inequality of time and refractions.

DIALOGUE.

DIALOGUE IV.

Of Quarter Repeating, and Chime Clocks, their uſe and management.

Chi. May there be any rules given for the ſetting, and keeping in order theſe motions, or may their uſe be known without experience?

Art. The uſe of Quarter Clocks is, not onely to ſtrike the full hour on a bell, but alſo to ſtrike at the end of every Quarter of an hour, ſo many blows on a ſmaller bell as are ſufficient to expreſs the number of Quarters that have paſſed ſince the hour laſt ſtruck.

Chi. Do they ſtrike on one bell onely or on more?

Art. They are made many times to ſtrike the Quarters on more bells then one, as many times on 2, 3, 4, 5, or 6. but let them ſtrike on never ſo many

they must strike them over as many times each quarter, as there are quarters passed since the striking of the last hour.

Chi. How doth the repeating Clock strike?

Art. They not only strike the hour and quarter, but also, immediately after the striking of each quarter, it repeats or strikes over again, on a different bell, the last hour that was strucken, by which you are given to understand, that it is 1, 2, or 3 quarters past that hour which was repeated; this Clock is of excellent use for the night.

There is another sort of repeating Clocks, which differs much from this before spoken of, the quarters and repeating, being both performed at the same time, and on the same bells; it strikes the quarters on three bells, and the hour bell never strikes above six: to understand the striking of this Clock you must observe this rule. Look on how many quarter bells it strikes whether on 1, 2, or 3, for so many

many quarters are passed since the striking of the last hour, as if it strike on one bell, then one quarter is passed; if on two bells, then two quarters are passed, if on three bells, three quarters are passed: then again, look how many times it strikes on any number of the aforesaid three bells, that is the hour that was strucken last; as suppose it strike five times on two bells, this signifies its two quarters past five or eleven as the time is, again suppose it strike six times one three bells, this signifies its three quarters past six or twelve, according to the time.

Chi. I understand not the meaning of its striking six or twelve, or eleven or five.

Art. The meaning is this, the Clock never striking but six, is the cause that at seven of the Clock in the morning it strikes but one; at eight, two; and at nine three; at ten, four; at eleven, five; and at twelve, six; which every one that hath common sence cannot imagine to be six at morning, or six at

evening, and therefore must needs be the next extream from six, *viz*, twelve.

Chi. How are these quarter and repeating Clocks to be managed in their setting?

Art. Only by the successive striking them round by lifting up their locking detents so often, till each part agreeth with the other in the performance of its office.

Chi. By what means may these detents be known, or how shall we find them, when there may be occasion to make use of them?

Art. To write of these things is but in vain, for 'tis unpossible (where there is such variety) to give certain and general directions your best knowledg herein will be from experience and the assistance of one well instructed therein.

DIALOGUE

DIALOGUE V.

Certain cases to be observed in all Clocks generally.

Chi. How often do Clocks require to be cleansed?

Art. All Clocks ought once every year to be cleansed from the filth and dirt they have contracted: they ought likewise to be once or twice oyled between each cleansing, for when the pevets are once grown dry they wear four times as fast as otherwise they would do, if they were kept moist with a little clean oyle, and are likewise then most subject to standing still.

Chi. Is not air and dust very Injurious to a Clock?

Art. Yes, and therefore all Clocks in the time of their going, ought to be kept as free as possible from both, the one will be apt to canker and

ruſt it, the other will exceedingly clog and foul it, therefore to avoid one ill convenience in part, let thoſe Clocks that move with lines, be ſure to be alwaies fitted with thoſe that are ſound and good, for when once the lines of a Clock begin to grow any whit worn they foul a Clock exceedingly.

Chi. 'Tis certain I have known Clocks that for two or three years have gone well without either cleaning or lining.

Art. This is likewiſe my experience, having known the like both in Clocks and Watches, but this was commonly the event, that when they were forced to make them clean they never went well after, for going dry ſo long without oyl, they were ſo extreamly worne, that twas unpoſſible they ſhould go longer.

This I fear will be the fate of thoſe long ſwing eight day Pendulums, ſo much at this day celebrated, for ſo long as they keep going well other things are

not

not conſidered, nor no regard is had to thoſe things that ſhould continue them in that placide eſtate of motion.

Chi. Which way muſt the hand be turned when we ſet either Clock or watch?

Art. When you ſet your pocket watches to the hour your beſt way is to move your hand backward (or contrary to the ſucceſſion of the figures) but if your movement be a Clock then you muſt not turn it thus backward as you do a watch, becauſe it will indanger the ſpoiling of it, but ſtrike it forward from hour to hour, till you come to the time you would ſet it at, then when you have ſo done put it ſomthing paſt the time you would ſet it to, and then bring it back again to the true time: as if your Clock were down, and your hand ſtood at eight, and you were to ſet it at a quarter paſt eleven; to do this ſtrike your Clock gradually from eight to nine, and from nine to ten, and from ten to eleven; then, to

ſet it at a quarter paſt eleven, turn it to half an hour paſt, and then bring it back to a quarter or the true time. The reaſon of this adviſe is, becauſe, if you put it forward when you ſet the hand, it will ſtand ſtill, for as long time as the ſhaking or playing thereof contains in time on the dial ring. I have known the hand of ſome Clocks and Watches, that have played forward and backward above a quarter of an hour, and ſo long will they ſtand ſtill, and not move the needle, when they are newly ſet, by turning the hand forward, whereas, if according to this direction, you put it backward, it will move immediately with the reſt of the work: the not underſtanding of this hath bread great miſtakes between many a gentleman and his Watch.

Obſerve alſo to ſet your Watch continually by one Sun-dial, becauſe 'tis ſeldome known that two Sun-dials go true together; ſo that, if you ſet it ſometimes by one, and ſometimes by another, you will never know when your

your Watch or Clock goeth right. Alſo obſerve further to ſet it (if poſſible) always to one hour on the ſame dial; becauſe many times the hour-lines give not true time alike, which, if it ſhould thus happen, yet ſetting it always at one hour, will prevent all miſtakes, or at leaſt all thoſe that are ſenſible.

Chi. What muſt be obſerved when Clocks or Watches want cleanſing or repairing?

Art. They muſt obſerve and be careful to ſend it to a workman, and not bring the Workman to it: many Gentlemen are of this humour, that when they have a Clock or ſuch like that wants cleaning or mending, the workman muſt come to their houſes to do it, which is a great miſtake, for 'tis impoſſible for a workman when he is from his tools to perform his buſineſs ſo exquiſitly as otherwiſe he might, ſo that they that deſire this are certain to have their buſineſs never well done.

I would alſo adviſe all perſons whatſoever

soever whose Clocks or Watches want reparations, that they give sufficient time after they are cleansed or mended, for the work-man truly to adjust them, for there is no man that can say, when he hath mended either Clock or Watch, that it shall go true, and perform well, till he have by sufficient tryal proved it and adjusted it.

Chi. Is it considerable whether or no we keep a true time in winding up Watches or Clocks?

Art. Not at all, you may wind them up at what time you please, or as often as you please, it matters not; only observe in Watches, and other spring movements to wind them till they stop, and not give over till you wind them wholly up; for if you do, you may chance to find alteration in their motion; for the spring, when first wound up, draws harder then he doth when he is somewhat settled, and if this happen in any place of the fuzey, that is not diminished proportion-

tionable to this impetuous, it must needs cause variation in the motion.

These are the most necessary, and chief directions, that can be given in writing, or that can be apprehended without example; nevertheless, whosoever is Master of either Clocks or Watches, shall certainly find great benefit by what hath been here delivered, if he be careful to observe them.

And though the rules, here delivered in this second part, are not so full and general as might be expected, yet they are as full as I thought convenient; for I did consider that every one, that make use of Clocks or Watches, knows also how to manage them, as to the common rules thereunto belonging, and therefore I did think it needless to insert those things that are already so commonly known, only I did give a little touch of some of them (that are most material) for methods sake: for the First and Third parts, and the Appendix, was that which

that

I chiefly designed, and may be worth the reading, if it be done with consideration; for they contain those things that are known, but to a very few, and perhaps not rightly understood by some of them, so as to apply them to use and benefit.

The End of the Second Part.

HOROLOGICAL DIALOGUES.

The Third Part.

DIALOGUE I.

Of the inequality of time in respect of Artificial motions: the nature of it, their times of erring with the quantity of their error, from whence several conclusions are drawn in reference to Clocks

Chi. What is the inequality of time and wherein doth it consist?

Art. The inequality of time consisteth not in the unequal length of days natural but in the

the unequal length of hours, as given on a Sun-dial which is a thing little sought after, and less understood by those whom it most nearly concerns.

Chi. This is a thing I never before heard of, nor can at present understand, how the hours given can be one longer then another, that is how the shadow on a Sundial can be longer time in passing from one hour to another at one time of the year, then it is at another, for my part I never observed it, nor cannot imagine which way to do it.

Art. There is no way possible to observe it, but by an exact Clock, that is regulated by a large Pendulum.

Chi. What is the reason of this inequality of time?

Art. In giving the reason or cause there is great difference, some make the reason of it to be the obliquity of the *Zodiack*, wherein the Sun moveth; others make the difference between the Suns true longitude, and his right ascention to be the absolute cause, others make the unequal motion of the *Sun* in the

Zodiack

Zodiack to be the cause (which I incline to) but the cause of this cause, I suppose, all are ignorant of, because God in his word never revealed it, and for any other way of knowing it, I suppose, 'tis so far from our attainment that the wisdome of the best Astronomer will in this prove but foolishness, however they may otherwise pretend.

Ch. What reason have you to believe the Suns unequal Course to be the cause?

Art. Because the Sun in its motion through the *Zodiack* passeth equal arches in unequal times, by reason of its swift and slow motion whereby he fulfilleth his course from *Libra* to *Aries* in 178 days (which is the winter half-year) but in passing from *Aries* to *Libra* he takes up 187 days (which is the summer half-year) being nine dayes longer in passing through the semicliptick of the summer, than he is through that of the winter, now the Sun being thus swift and slow in motion cannot

not give a true and constant hour by its shadow one a Sundial for the motion of the primum Mobil finisheth its course in exact times, *i. e.* in twenty four hours which well agrees with the Suns mean motion near the equinoctial, but when the Sun is in its swift motion, as it happeneth when inclining to the winter Tropick, then there is more time contained in twenty four hours, as given on a dial, then there was in the equinoctial, and so by consequence every particular hour in the twenty four must be somewhat longer then those in the Æquator: but when she happeneth to have slow motion as from *Aries* to *Libra* then there is not so much time contained in twenty four hours as there is in the Æquator, and so by consequence every hour must also be shorter.

Chi. How this swift and slow motion of the Sun should cause this inequality in time I cannot well understand.

Suppose there were on an instrument

ment two circles drawn concentrick, and the outmoſt Circle ſhould be graduated into 360 degrees, and every degree into ſixty minuts, and ſuppoſe that upon this circle thus graduated, there ſhould ſome certain figure move, as it were naturally from West to East, which in Twenty four hours ſhould move almoſt Fifty nine minutes of a degree; ſuppoſe likewiſe that in this time of moving Fifty nine minutes, the innermoſt circle ſhould compleatly the ſame way make one revolution, and ſhould continue ſo to do; that is, ſhould always compleat its revolution, within it ſelf in Twenty four hours, in which time the other moves fifty nine minutes of a degree; then ſuppoſe this figure on the graduated circle ſhould increaſe its motion, and ſhould move Sixty one minutes of a degree, in the ſame time as it before moved but Fifty nine; this muſt needs cauſe the innermoſt circle (who before in twenty four hours finiſhed its courſe from one conjunction to another, when the figure

moved but fifty nine in twenty four hours) to be longer time now, then twenty four hours, in passing from one conjunction to another, because the figure moveth faster, and so by consequence, requires more time to be overtaken then it did in its mean motion, the same reason is also for its slow motion; for if the figure move less then fifty nine (as suppose fifty eight or fifty seven minutes) there is less time required for the prymoby like motion of the innermost circle to overtake it, then twenty four hours.

Chi. What do you infer from hence?

Art. From hence we may infer, that if the hours given by a Sun-dial, increase or decrease in length, according to the slow or swift motion of the Sun, that then tis impossible for the most exact Clock that ever was made, to keep time with a Sun-dial, but there will be difference according to the time of the year and course of the Sun.

Chi. How is it then possible to

justen

juſten a Clock, exactly to the hour.

Art. Tis poſſible (when a man rightly underſtands the courſe of the Sun) to juſten it ſo, as that if it be ſet to a Sun-dial at any time it may be right with the ſame dial that time twelve month, but to juſten it ſo as to keep touch with a dial the year round is unpoſſible.

Chi. At what time will they differ?

Art. If a Pendulum truely adjuſted (ſo as to come right that time twelve month without ſetting) be ſet to the hour in *January*, it ſhall in *June* following be too ſlow by the ſame dial; if it be ſet in *June* to the hour, in *January* following, it ſhall be too faſt, but if it be let go the year round, it ſhall in one half year gain or loſe what it loſt or got in the other, and ſo at the years end come right to the time it was firſt ſet at.

Chi. What may be the quantity of their error?

A. From *June* to *January* (if it be well adjusted) will nevertheless gain about forty four minutes, or almost three quarters of an hour; from *January* to *June* will lose near the same time; if set to a dial in *March*, it may lose by *June* something above a quarter of an hour, *viz*, twenty two minutes; from *June* to *September* will gain as much and come right again; from *September* to *December* it will gain about twenty two minutes, but from *December* to *March* will lose it and come right again, Whence observe that Clocks set to the hour, when the Sun is in either of the tropicks, continues gaining and losing the whole year round, and never agree with the same dial, till that time twelve month: but if they are set when the Sun is in either of the equinoctial points, then they may agree with the same dial twice in the same time or year, and their gaining and losing will never be so extream, as when set in the tropicks,

tropicks, for if be ſet in *March* (or the equinoctial of *Aries*) it ſhall have loſt in *June* but twenty one or twenty two minutes, and in *September* following it will agree with the ſame dial again, from thence to *December* twill gain as much, and from thence to *March* it will loſe it and come right again; ſo that from hence we may likewiſe conclude that thoſe Clocks, which go to a quarter of an hour or ſomething more in three months, are the neareſt that can be brought to keep true time with the Sun, let them be of what form, kind, or price ſoever.

Chi. What is the moſt true and exact way of juſtening Clocks by the Sun?

Art. If you would juſten a Clock exactly to the Sun, ſo that a twelve month after it may agree with the ſame dial (if ſet when the Sun is in the tropicks, or agree with the ſame dial twice in the year, when ſet in the equinoctials) do thus, in the equinox of *March* let it be ſet to a true

dial that sheweth minutes, and when the Sun is in the meridian; then in *June* following observe the difference betwçen your Clock and dial, which if it be about twenty two minutes too slow then conclude it goeth well, but if it be more then twenty two minutes or less, then you must rectifie it accordingly, as hath been formerly taught, and thus you may rectifie it, according to any other time, if you consider the difference that happeneth after so many months going, from any time of setting.

DIALOGUE II.

Of Refractions what it is, and when it happeneth, with several conclusions drawn from it, in reference to Clocks.

Chi. What is the refraction of the Suns beams, and how is it caused?

Art. Refraction of the Sun is when the

ſhe appeareth higher in altitude then indeed ſhe is, and is cauſed by the moiſt and humid vapours which continually ariſe from off the earth, which naturally do repreſent all things, that are ſeen through them, to be larger in bulk and higher in altitude then indeed they really are, this makes the *Sun*, *Moon*, and *Stars*, when they firſt ariſe, to appear ſo large in magnitude, which continually diminiſheth according as they aſcend above the horizon, till being elevated above all vapours, they are again reduced in our appearance to their natuaral magnitude, and as thoſe vapours make them appear to us of greater bulk and magnitude then otherwiſe they would, ſo they cauſe them alſo to appear higher in altitude: ſo that we ſee the ſun viſibly riſen before ſhe is naturally above the horizon.

Chi. How is this proved?

Art. It may be proved thus: take an Horizontal Dial, that is large and truly drawn, place it exactly in its

true position, which having done, let a Pendulum Clock, that keepeth true time, be (about twelve of the Clock) set exactly to it; the next morning, if the Sun shine, observe how they agree, and you shall find that at the first rising of the Sun there will be much difference, which will by little and little diminish, according as the Sun gets above the strength of those vapours, till at last they come exactly together, which could not be, if her altitude were not by these refractions, made apparently higher than her true place.

Chi. What conclusions may be drawn from hence?

Art. Since it is so that those vapors make the Sun at his rising or setting to appear higher to us than naturally she is, this must by consequence give a false shaddow on all Sun-dials, both at its rising and setting, because the hour lines drawn on Sun-dials, are designed to receive the shaddow of the Sun from its true place, and not from his apparient; and so by consequence all

Dials

Dials whatsoever cannot at those times give the true hour, because they receive not their shaddow from the *Suns* true place, but from his apparient; therefore if your Watches and Clocks agree not with your Dial, you are not to conclude the fault to be in their motion (if they have gone well before) but in the refracted shining of the Sun.

Chi. What altitude may the Sun attain before we may put confidence in a Sun-dial?

Art. For this I shall give you a Table made by my observation as near as possible to the truth.

A Table of the Suns refraction in time, according to the degrees of Altitude.

⊙ Alt.	Differ. ′	″	⊙ Alt.	Differ. ′	″
0	— 18	— 00	12	— 04	— 30
1	— 14	— 00	13	— 04	— 15
2	— 11	— 00	14	— 04	— 00
3	— 09	— 00	15	— 03	— 40
4	— 08	— 00	16	— 03	— 20
5	— 07	— 30	17	— 03	— 00
6	— 07	— 00	18	— 02	— 35
7	— 06	— 30	19	— 02	— 00
8	— 06	— 00	20	— 01	— 20
9	— 05	— 30	21	— 01	— 00
10	— 05	— 00	22	— 00	— 30
11	— 04	— 45	23	— 00	— 00

The use of this Table is thus, first find the Suns altitude in the left hand column, intituled ⊙ *altitude*, and right against it you have the minutes and seconds, which those dials vary when the Sun hath such degrees of altitude; as for example, when the Sun first appeareth,

a dial will differ from the true time 18 minutes; when the hath 3 degrees of altitude, the difference is 9 minutes; when she hath 9 degrees of altitude, the difference is 5 minutes 30 secants, *&c.* so that it will not be safe setting either Watch or Clock to the hour given on a Sun-dial, till the Sun have attained 20 degrees of altitude above the Horizon, till which time the refraction is something sensible.

Chi. Tell me precisely what hours are fittest for that purpose?

A. The best times for setting either Clock or watch to the time on a Dial, is in *May*, *June*, and *July*, between the hours of 7 in the morning and 5 in the afternoon, in *April* and *August* between the hours of 8 in the morning, and 4 in the afternoon; in *February* and *September*, between the hours of 10 and 2, the other months 'twill not be safe setting them till near noon.

Chi. Suppose a watch should be set to a Sun-dial betimes in the morning, what then?

Art.

Art. Then it will not go right with the ſame Dial all the prime part of the day after, but will differ as much as the refraction was, when it was ſet to the ſame dial.

Chi. are not theſe refractions always equal throughout the year ?.

Art. No, they are greater in Winter than in the Summer, greater in moiſt weather than in dry, greater near Seas or large Rivers than on the remoter parts of dry land, and greater in the morning than they are in the evening, all which being duly conſidered, may prove of good uſe for the buſineſs for which this diſcourſe hath deſigned it, *viz.* The true keeping, and right managing of all Clocks and Watches whatſoever; ſo that whenſoever you ſhall find your Watches or Clocks differ in the ſame day from your Dial, you may by knowing the reaſon of it prevent thoſe miſtakes which otherwiſe might ariſe ?

DIA-

DIALOGUE III.

Of the Spring, its definition, nature and defects, with the effects thereof in Clocks and Watches.

Chi. From whence do those Movements that go without weights receive their motion?

Art. From a spring.

Chi. What is a spring?

Art. A spring is a certain thin plate of steel, drawn by the hammer to a sufficient length, breadth, and thickness, according as the proportion of draught (which is designed to it requires) this being exactly wrought, and artificially tempered, is wound up in the form of a spiral line, not close together, but at a certain distance, after which it is conveyed into its barrel, where it lyeth something closer together in the outward circumference than in the center, having the

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one end fastened to the barrel, and the other to the arbor whereon the barrel moveth.

Chi. When it is thus fitted to its work, how doth it perform or draw, so as to give motion to the wheels after it is wound up?

Art. When it is first wound up, it compresseth it self in the center, (as before it did in the circumference) but being by the temper made as it were free Denizen of a certain Orb, it never resteth till by extension it hath attained to its first place, which it doth not in an instant, but by degrees as the motion of the work, which it draws along with it, will suffer it to move round.

Chi. Is the draught of a spring equally in all places alike, or doth it differ according as it may be strained?

Art. The spring is always strongest when first wound up, and weakest when returned to its natural position; from whence it happeneth that the

the fuzey (by which the ſpring draweth the work about) is made commonly in the ſhape of a Counical ſcrew, by which means this unequal draught is regulated and made alike equal; for when the ſpring is firſt wound up, and its draught ſtrongeſt, there the fuzey is leaſt, and ſo as the ſtrength of the ſpring decreaſeth, ſo the bigneſs of the fuzey increaſeth, by which means the wheels move moſt commonly with a pretty equal motion.

Chi. Is it poſſible ſo to adjuſt a fuzey to the draught of a ſpring, that there ſhall be no alteration of time in thoſe Watches which it moveth?

Art. The anſwer to this your queſtion is a thing of great conſequence, and deſerves diligently to be enquired into: my opinion is, that the ſpring like a wife Maſter-fencer, hath reſerved to himſelf ſome certain unlucky tricks (which it's moſt diligent obſervers cannot attain to the knowledge of) that ſo it may be able

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on occasion to give a foil to those that think themselves sufficiently able to overcome all its difficulties: Certain it is that those occult defects, which are yet remaining in the spring, are the very scourge and disgrace of Clock-makers, working those effects in the motion of Watches, which the most sound workman is not able to remedy, it being equally as unpossible to make a Watch go always true, as to have light and darkness both in the same place at the same time.

Some Watches there are that for 6 or 8 days will go indifferent right, and after that it may be check and go too slow, and another time too fast, and seldom continue in one estate of motion, although it have always one bent of spring; this is often remedied with a new spring, but never with the same.

Others there are that shall never go well 24 hours together, but shall either gain or lose in spite of Art.

Springs many times draw well for a time, and then faulter at last, as is seen

ſeen in many new Watches, who go well when firſt ſold, but afterward upon ſettling of the ſpring have moved very irregularly, which may be rectified by another new ſpring; however the Work-man is commonly on ſuch occaſions blamed, though the fault be none of his, but is rather (if in any) the fault of the ſpring-maker.

Chi. How is it the Spring-makers fault?

Art. Either he worketh them not truly to an equal thickneſs, or giveth them not a true temper in all places alike, or it may be leaveth them too high, or taketh them down too low, all which may be the cauſe of their unplacent motion; for if they compreſs themſelves more in one place than in another, it cannot in its extenſion move ſo free from jerking or twitching, as thoſe that are compreſſed alike in all its parts, which ill conveniencies though they many times are cauſed through the Spring-makers neglect, yet I dare not affirm it to be always his

fault; for I believe, let them take all the care that possibly they can, yet the nature of steel is such, that it will not in all places take temper alike, which how the best work-man in this way will be able to remedy, I know not; however it is certain, that where a spring is wrought with care, let it be what steel it will, yet it must needs prove better than those that are wrought with neglect.

Chi. Are all springs troubled with those defects?

Art. No, all are not, in so high a measure, for then 'twere unpossible any Watches should go true. Some are far better than others, and by chance a man may light on some that are purely good, but this is very rare, but for the most part, they are either more or less defective, and so by consequence those Watches that are moved by them, keep either a certain or uncertain time, according as the springs are in goodness that move them, always having consideration to the goodness

goodneſs of the work; from all which we may conclude that the pains and care of Watch-makers ought to be very great that bring thoſe Movements to any true performance, and if thoſe that buy them, were as careful to pay them for their trouble, it would in this Art produce great effects.

Let me adviſe all Gentlemen (and others) whoſe fortune it hath been to light on thoſe Watches, that by the care of a good Workman, are brought to perform well, that they value them accordingly, and take great care that they do not by violence put them into diſorder, it's poſſible that a Watch may go near the true time, though not ſet in many days, this account excellent; but if it go ſo well as to require ſetting but in two or three days, this is very conſiderable; and where you have one that goes better you may have two that go worſe; therefore priſe theſe alſo, and account that work that performs thus to be good work, and carefully finiſhed.

Note, That Pendulum Clocks or Watches which are drawn by ſprings, are not ſubject to thoſe irregular motions as ballance movements are.

DIALOGUE IV.

Some Enquiries into the Nature of the Pendulum, with the method of finding their ſeveral lengths.

Phi. The Pendulum being one of the moſt exact means yet diſcovered for the keeping of true time, it would be time well ſpent to enquire ſomething into the nature of its motion, both as to its vibrations and terms of ſuſpenſion.

Art. As for the vibration of Pendulums ſuſpended at any length, 'tis certain that the times of it, vibrations natural to any Pendulums length, are ſo limited and prefixed, that it is impoſſible to make it move under any other

other period than that only one, which is natural unto it, let any one try all the ways he can to encreaſe or decreaſe the frequency of its vibrations, and he ſhall find his labour all in vain, provided he encreaſe or decreaſe not the arch of its recurſions; that is, that he remove it not farther or leſſer from its Center of gravity, than ſuch a certain number of degrees.

Chi. You need not have made any exception, for 'tis well demonſtrated by one of the Ancients, that if it be removed from the Center of gravity, any number of degrees whatſoever from one to ninety, yet the number of vibrations in the ſame Perdulum ſhall not encreaſe or decreaſe: His words are theſe, 'That the Moveables that 'ſhould deſcend along the Cords, that 'are Subtenſes to any Arch, muſt ne-'ceſſarily paſs them all in equal times, 'as well the ſubtenſe under an hundred 'an eighty degrees (that is the whole 'Diameter) as the ſubtenſes of an hun-'dred, ſixty, ten, two, or half a degree,

'four minutes: ſtill ſuppoſing that 'they all determine in the loweſt point 'touching the Horizontal plain. An effect which hath in it ſo much of wonder, by how much at the firſt apprehenſion one would think the contrary would follow; for the term of the beginning and end of the motion being common, and the right line being the ſhorteſt that can be comprehended between the ſaid terms, it ſeemeth reaſonable that the motion made by it ſhould be finiſhed in the ſhorteſt time, which yet is not ſo, but the ſhorteſt time, and conſequently the ſwifteſt motion, is that made by the Arch, of which the ſaid right line is Cord.

Art. But if this ancient Writer had had the ſame opportunity of experiencing theſe things as we have now, he would have been of another opinion: For to confute this, tryal was made by a Pendulum about ſeven foot long, which vibrated (by a Clock ſhewing ſecants) 41 times in a minute, at which time it ſwong or moved

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in an Arch of four inches, the same *Pendulum*, at 12 inches Arch vibrated but 40 ¼ the same at 10 foot Arch vibrated but 39 times, the same Pendulum at the whole Semi-arch vibrated but 37 times, so that here was four blows difference in the same *Pendulum*, when vibrating in different arches, which clearly prove that *Pendulums* cannot perform all its vibrations great, lesser, and least, under times precisely equal.

Besides, 'tis clearly apparent that ordinary pendulum Clocks and others, whose pendants are but short, that when through foulness or natural wearing, they fetch not so large a compass as when they are clean, and in order 'tis then I say apparent that their motion is swifter than at other times.

Chi. It's probable that your Mechanical observations may be of more weight than the best rules of Art in this kind, for the truth is, if rules of Art will not keep touch with the Mecha-

nicks, 'tis not to be regarded; in the next place let us consider the vibrations of Pendulums of different lengths in the same time, what proportions they bear?

Art. As to the times of the vibrations of pendulums suspended by verges of different lengths, those times are in subduple proportion to the the lengths of their verges, or if you will, the lengths are in duplicate proportion to the times; that is, are as the squares of the times: so that if for example the time of the vibration of one pendulum is double to the vibration of an other, it followeth that the length of the rod of that is quadruple to the length of the verge of this, and in the time of one vibration of that, another shall make three vibrations when the verge of that shall be nine times as long as the other. From whence doth follow, that the length of the verges have to each other the the same proportion as the squares of the number of vibrations that are made in the same times have. *Chi.*

Chi. Then if I have rightly underſtood you, I may eaſily know the length of a pendulum hanging at never ſo great heighth, although the ſublime term of ſuſpenſion were inviſible to me, and I only ſaw the lower extream, for if it ſhould be ſet on vibrating too and again, and a friend telling ſome of its recurſions, and *I* at the ſame time tell the recurſions of another pendulum ſuſpended, on a verge preciſely a yard long, by the numbers of the vibrations of theſe pendulums made in the ſame time: I will find the length of the pendulum whoſe term of ſuſpenſion I know not, as for example, ſuppoſe in the time that my friend hath counted twenty recurſions of the long pendulum, and I had told two hundred and forty of mine that is a yard long: ſquaring the two numbers of 20 and 240. which are 400 and 57600. I will ſay that the long ſtring containeth 57600 of thoſe meaſures of which my ſtring containeth 400.

Art.

Art. You are in the right, nor will you be miſtaken one inch, eſpecially if you take a great number of vibrations: by the ſame rule alſo you may (having the length of any one pendulum from its upmoſt ſuſpenſion to the Center of the bob, and the number of its vibrations in a minute) find out the length of a pendulum that ſhall vibrate any number of blows in the ſame time; ſuppoſe I had a pendent three foot long that vibrated 62 times in a minute, and I have occaſion for to find out the length of a pendulum that ſhall vibrate but 20 in a minute. Do thus, ſquare the two numbers 62 and 20, which produce 3844 and 400, now divide 3844 by 400, the quotient is $9\frac{61}{100}$ therefore I ſay that this pendulum to vibrat 20 in one minute, muſt be $9\frac{61}{100}$ times as long as my ſtandard pendulum, which being 3 foot, the other will be 28 foot 8 inches long from the term of ſuſpenſion to the center of the bob, and thus you may do for any other whatſoever, by obſerving what

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hath been here delivered. For ſo often as the ſquare of any number of vibrations is contained in the ſquare of another made in the ſame time, ſo many times muſt the length of that pendulum (which made the greateſt ſquare) be contained in the length of the other which made the ſmaller ſquare.

By the ſame rule inverted, you may, by having the lengths of two pendulums, and the vibrations that one of them makes in a minute, find out alſo the times that the other ſhall vibrate in the ſame time: for if you have a pendulum whoſe number of vibrations in a minute you know already, and would know the vibrations that another pendulum, which is longer, ſhall make in the ſame time: Conſider how often the length of your ſhort pendulum is contained in that longer pendulum, and ſo often ſhall the ſquares of that long pendulums vibrations be contained in the ſquares of thoſe vibrations made by the ſhort pendulum in the ſame time: So likewiſe if you have a

long

long pendulum whose vibrations you know, and you would know how many vibrations a pendulum that is shorter, shall make in the same time, look how much your first pendulum is longer than your short one: so many times greater must the square of your short pendulums vibrations be above those made by your longer pendulum in the same time.

Note, that great care ought to be had in taking the true length of your pendulum, from the utmost term of suspension to the center of the bob, and likewise that your pendulums bobs be of an equal weight, or reduced thereunto by rules of proportion.

DIA-

DIALOGUE V.

Of the Clock-bell, the cauſe of its ſounding, with the nature thereof, proved by reaſon and experience.

Chi. The nature of ſounds in my opinion, is one of the moſt ſubtle pieces of nature, being equally myſterious with that of light and colours, and a thing that hitherto hath been but ſuperficially obſerved, and as yet very little minded, and though we cannot expect the true reaſons thereof can be ſoon attained, yet to make ſome certain enquiry thereinto will not be time miſpent; therefore to come the more cloſe to our intended deſign, what is your opinion concerning the firſt creation of ſound in a Clock-bell.

Art. Air, being the moſt pure Medium of all ſounds, muſt be wrought upon by ſuch means as are ſolely neceſſary for the creation of a ſound, which

which will be effected, if tortured by moſt quick and ſubtile motions; hence it happeneth that Bells, having by means of the percuſſion of the hammer, a trembling wrought in the minute parts, which by its quick and ſubtile working upon the air in the concavity of the Bell, produceth a tone or ſound.

Chi. What is the reaſon of the trebbleneſs or baſeneſs of tones, one above another.

Art. The trebbleneſs or baſeneſs of tones in Bells, is from two cauſes; Firſt, from the quantity of air that is percuſed or contained in the concavity of the Bell Secondly, from the quickneſs or ſloweſs of the percuſion. To prove this, take Bells of different greatneſs, but the ſame thickneſs in metal, and you ſhall find them to produce different tones, according to the quantity of air contained in their concavities Again, take Bells of the ſame bredth and depth, but differing in their metal, and you ſhall find that Bell

Bell whose metal is thinneſt, to give the moſt baſe ſound, and thoſe that are thickeſt in metal, ſhall produce the moſt treble ſound; for the thicker the Bell is, the more quick and ſharp is the percuſſion of the air within it, which produceth the treble tone, but the thinner the Bell, the more weak and ſlow is the percuſſion, which according to its nature, produceth a more baſe or flat tone.

Tones are the ſame in Bells of ſeveral weights, but differently majorated according to the magnitude of their bodies that produce it, for you ſhall have a Bell of a pound weight carry the ſame tone as a Bell of two or three hundred, but not in the ſame ſtrength to be heard ſo far; ſo likewiſe it's poſſible that a Bell of ten pound weight may produce the ſame tone as a Bell of four or five thouſand weight, but yet their different majoration will be according to the proportion of their metals.

Chi.

Chi. May not the ſound of two Bells of the ſame weight be different in majoration, that is to be heard, one farther than another.

Art. Yes, 'tis certain they may; for always obſerve, the ſharper the tone is, the farther the ſound is heard, being more active and ſprightly than thoſe tones that have a more dull and ſolitary note; from Bells of the ſame weight.

From what hath been delivered, it will be worth the while to draw ſome heads of enquiry.

Firſt, what juſt proportion of air in the concavity of a Bell, ſhall be ſufficient to produce a whole Muſical tone, and what proportion will hold in every tone.

Secondly, what diminution of ſubſtance in a Bell of any weight, will be ſufficient to make that Bell a tone more baſe? or what diminution of depth ſhall be ſufficient to make it a note ſharper?

Thirdly, what bore a Bell of any weight requires to majorate the ſound thereof

thereof to the higheſt degree poſſible?

Chi. How do ſounds of Bells ſpread or move in the air?

Art. All ſounds of Bells ſpread themſelves into a ſpherical area, where there is no impediment; otherwiſe they move more oval, if carried by the violence of winds, or otherwiſe obſtructed.

Though ſounds of Bells ſpread themſelves ſpherically, yet they go fartheſt in the fore lines from the firſt local impulſion of the air.

All reflections concurrent, make ſounds greater (but if the body that createth the reflection be clean and ſmooth, it maketh them ſweeter) as is ſeen in large and ſtately Halls or Churches, where the leaſt voice is ſoon heard.

Soft and foraminous bodies in the firſt Creation of the ſound of Bells, will dead it, as is apparent where hangings are uſed, but in paſſage of ſounds, they will admit it better than hard bodies.

Querie. Whether the ſound of Clock-bells may not be majorated by means of its paſſage through certain trunks on purpoſe artificially placed for the ſound to paſs through, that by the penning thereof it may come forth more ſtrong and loud, this would be a thing of excellent uſe, if it could be effected?

Querie alſo. What weight of Hammer is beſt for to make the Bell give forth its true and natural ſound? for 'tis obſerved, that if the Hammer be too heavy or too light for that quantity or quality of metal contained in a Bell, they give not their ſound ſo clear and full as when due proportion is obſerved.

FINIS.

AN

APPENDIX

WHEREIN IS

Contained a METHOD

OF

Calculating all Numbers

FOR

WATCHES.

Written Originally by that famous Mathematician Mr. *WILLIAM OUGHTRED*, and now made Publick.

By *J. S.* of *London*, Clock-maker.

LONDON,

Printed for *Jonathan Edwin* at the *Three Roses* in *Ludgate-street*, 1675.

TO THE

READER.

THe method following was many years ſince Compiled by Mr. *Oughtred* for the uſe of ſome Ingenious Gentlemen his friends, who for recreation at the Univerſity, ſtudied to find out the reaſon and knowledge of Watch-work, which ſeemed alſo to be a thing with which Mr.

Mr. *Oughtred* himself was much affected, as may in part appear by his putting out of his own Son to the same Trade, for whose use (as I am informed) he did compile a larger tract, but what became of it cannot be known.

As for this work it self, *I* need not commend it, because it hath in the front Mr. *Oughtred*'s Name, which alone is sufficient to bespeak its worth; nay, it would in my Judgment be an *I*njury to the fame of that excellent Author, thus to seem to argue a distrust, as if any thing that were Compiled by him should be in it self so deficient as to borrow

a

a ſupply of its own praiſe from another's Pen.

It ſufficeth me therefore to let you know 'tis his, Compiled by himſelf for the ſame uſe for which it is now Publiſhed, and is without doubt a work of that worthineſs, that whatſoever Artiſt ſhall truly and rightly underſtand it, ſhall alſo gain moſt excellent benefit by it.

The Method it ſelf indeed as it is by him delivered, relates only to Watches, which notwithſtanding may be as aptly applyed to any other number whatſoever required in the Art of Clock-work, as every ingenuous man will ſoon find.

I have only one word more, and that is, that whosoever hath a desire to attain this Analletical way of Calculation must consult that Book, *Intituled Clavis Mathematica*, written by the same Author, wherein they may be fully instructed concerning the understanding of it.

Thine,

J. S.

APPENDIX.

I.

Of Movements or Automata.

1. IN every Movement ſome of the wheels and pinions effect or incite the motion, and ſome others do determinate or ſpecificate the ſame.

2. They which effect the Motion are firſt, the great wheel (*A*) with the fuzey, which moveth (*e*) the pinion of the ſecond wheel, (*E*) which again moveth (*i*) the pinion of the third or Cantrate wheel, (*I*) which again moveth (*o*) the pinion of the Crown wheel, (*O*) which laſtly, moveth the ballance.

3. They

3. They which ſpecificate the Motion, are the pinion (α) fixed to the Arbour of the great wheel moving, (B) the Dial wheel having its revolution in (H) hours or parts of time together with ſuch intermediate wheels and pinions as ſhall be found neceſſary.

4. If the number of any be divided by the number of another wheel moving it, or moved by it, the quotient ſhall ſhow how many revolutions of the Diviſor are to one turn of the Dividend, and how much of the Dividend goeth in one turn of the Diviſor, as if $\frac{A}{c}=\gamma$ it ſhall be $A=\gamma E$ that is one turn of (A) is equal in time to (2) turns of (E) and $\frac{A}{2}=E$ that is ($\frac{1}{2}$) part of (A) is equal to one turn of (E) Again, if $\frac{B}{\alpha}=\beta$ it ſhall be $B=\beta\alpha$ that is one turn of (B) is equal to (β) turns of (A) and $\frac{B}{3}=A$ that is ($\frac{1}{3}$) of (B) is equal in time to one turn of (A &

5. Where-

5. Wherefore in every motion the number of the two wheels do make a Ratio or fraction, whereof the Motrix is the Nrator in those that effect the motion; as $\frac{A}{e}=2.\frac{E}{i}=8.\frac{I}{o}=5.$ But in those that specificate the motion it is the denominator as $\frac{E}{\alpha}=\beta$ &c.

6. A view of the wheels and pinions.

Mobiles. 4

O
o) *I* (5
i) *E* (8
e) *A* (2
Motrix *α*) *B* (*β*

Mobiles. 5

O
o) *V* (*o*
u) *I* (5
i) *E* (8
e) *A* (2
Motrix *α*) *B* (*β*

7. $A=2E=28I=285,O$ which are so many turns of *(O)* if it be taken for the wheel, or so many notches of the wheel, if it be taken for the number; which is also to be understood of the rest of the Letters, *viz.*

E=

$$E = \frac{A}{2} = 8J = 85,O$$

$$J = \frac{A}{28} = \frac{E}{8} = 5,O$$

$$O = \frac{A}{285} = \frac{E}{85} = \frac{J}{5}$$

$$8.H = \beta = \beta A = \beta_2 E = \beta 28 J = \beta 285,O$$

$$A = \frac{B}{\beta}. \quad E = \frac{B}{\beta_2}. \quad J = \frac{B}{\beta 28} \quad O = \frac{B}{\beta 285}$$

9. $285,O = D$ by which note I signifie the number of the notches of the Crown wheel (O) gone in one turn of (A) by number 7. wherefore $A = D = \frac{B}{\beta} = 2L = 28J$.

10. $\frac{\beta 285,O}{H} = \frac{8D}{H} = D$ which is the number of notches of the Crown wheel (O) is gone in one hour, or $\frac{1}{H}$ for by number 8. H $\beta 285,o :: 1. \frac{\beta 285,o.}{H}$

$E = \frac{1}{2}D$. $J = \frac{1}{28}D$ 11. Our

11. Out the former propoſitions, theſe follow, *viz.*

$\frac{1}{H} = \frac{\beta}{H}\ A = \frac{\beta 2}{H}\ E = \frac{\beta 28}{H}\ \mathfrak{J} = \frac{\beta 285}{H}\ O = D$

12. $H.\ \beta \frac{B}{a} :: \mathfrak{D}.D :: C.\ \mathfrak{J}.$ for if in (H) hours are (β) turns of (A) or $(\beta\mathfrak{D})$ nothes gone $(\mathfrak{P}$ to$)$ then in one hour $\left(\frac{\beta}{H}\right)$ turns of (A) or $\left(\frac{\beta\mathfrak{D}}{H}\right)$ nothes gone 8 then alſo in (c) hours (which is the continuance of the watches going) are gone (T) turns of (A) or turns about the fuzey.

13. Wherefore the leſſer (β) is taken, the longer ſhall (c) be at an equal (T).

II. *Of*

II.

Of finding out fit numbers for the wheels and pinions.

14. ANy two fractions, whose terms are proportional, perform the same motion $\frac{2}{1}$ or $\frac{36}{18}$ or $\frac{45}{5}$ the lower of which is for the pinion, and the upper for the wheel.

15. The same motion may be performed either by one wheel and one pinion, or else by many wheels and many pinions; so that the product of all the wheels, be to the product of all the pinions, as that one wheel is to that one pinion, as in this example $\frac{1440}{18} = \frac{36}{18} \times \frac{8}{1} \times \frac{5}{1}$ or $\frac{36}{4} \times \frac{8}{7} \times \frac{70}{10}$ neither is it any matter in what order the wheels and pinions are set, or which pinion standeth under every wheel.

16. And these two factors (36x8 being given may be manifestly varied by this rule, if two factors given be divided by any two other numbers, which

which will measure them, and the quotients be multiplyed by the altern divisions, the product of these two last numbers found shall be equal to the product of the two fractors given

Thus for 36x8 you shall have found

9 8
36 x 8
4 1
32 9

32 x 9 for 1x9. 1x8::4x9.4x8

17. If fit proportional numbers cannot be had by any of these three last rules, you may seek some Ratio, as near unto it as possible in this manner, say as one of the two numbers given is to the other, so is 360 to a fourth divide that fourth number, as also 360 by 4. 5. 6. 8. 9. 10. 12. 15 or by which of them that bringeth a quotient neareſt to an integer; as if two numbers given be $\frac{147}{170}$ which are too great to be cut in small wheels, say therefore 170. 147::360. 311

147. 170.::360. 416

6(

6)311(52 8)311(39 8)360(45
360(60 360(45 416(52

Wherefore for the two numbers 147 and 170, you may take 52 and 60, or 39 and 45, or 45 and 52, &c.

18. If two wheels of a motion touch without they move contrariwise, but if they touch within, they move the same way.

19. In lesser Watches *D* must be at least 8000, but in greater *D* may be 4000, for in lesser pieces a swift train is more commendable, and in greater pieces a slower.

20. To give numbers to a Watch of a swift train about 10000, for *D* you must have *T* 12. and *C* 16 hours, and *O* 17. say (by number 12) *T. C:: D.* ⊅. that is, 12. 16::10000. 13333=⊅, and because (by number 9) ⊅=285,0. 17) 13333(784 =285. which are three quotients for finding the three pinions, seek therefore three numbers, which being multiplyed together, produce 784, very near

near let them be 11. 9. 8 the product whereof is 792=285. Correct them 792x17=13464=D. Correct and say *T. C* :: D. *D.* that is, 16, 12 :: 13464. 10098=*D.* Correct also say *C. T*:: *H.*$\frac{\beta}{\alpha}$ (by number 12) that is, 16. 12::12. $\frac{2\beta}{\alpha}$

Then by the 3 quotients assumed 11. 9. 8. find out the 3 wheels (*A.* 55) *E.* 45) *F.* 40) and the 3 pinions (*e.* 5) *i.* 5) *o.* 5) as is done on the side.

α, 4)36(*B*(3β
E 5)55(11, 2
i, 5)45(9, 8
o, 5)40(8, 5
O)17

D, 13464
D, 10098
T, 12. 6. 16

21. To find how long this watch before found, may be made to go by slackening *D* to 8000 (by number 12) say D. *D*:: *H.*$\frac{B}{\alpha}$ :: *C. T.* that is 13464. 8000:: 12 $9\frac{6000}{13464}\frac{B}{\alpha}$, $3\frac{6}{5}$ again, $\frac{36}{5}$. 12:: *T* 12. *C* 20, it may therefore be made

to go 20 hours by altering ☽ to 36 and ☌ to 5.

22. To give numbers for a Watch of about 5000 for *D*, that may have *T* 12, *C* 170, and *O* 17; this work is as in 20, say therefore 12. 170 :: 5000. 70833 = ☽ 17) 70833 (4167 for 2850, because three quotients will yield too big a number for wheels let them be 10. 8. 8. 6. $\frac{3}{5}$. which multiplyed continually together with 17, make 71808 = ☽ Corr. and say 170. 12 :: 71808. 5069 = *D* Corr. also and say 170. 12 :: $12\frac{144}{170}$. $\frac{45}{53}$ or $\frac{38}{45}$ $\frac{B}{\alpha}$ for

144. 170 :: 360. 425
170. 144 :: 360. 305 & $\frac{3}{5}$ divid. by 8.

This Watch hath 4 wheels besides the Crown wheel *O*, which by help of their quotients, are with their pinions found out as here in the side is set down.

α 53) 45 B ($\frac{45}{53}$ ß
e 6) 60 (10 2
i 6) 48 (8 8
V 5) 40 (8 5
O 5) 33 ($6\frac{3}{5}$ O
O 17
☽ 71808
D 5069
C 170. *T*. 12

23. This

23. This Movement being given, *viz.* wherein are four wheels, beſides the Crown wheel, it is demanded how long it may be made to go with a good train of about 9000 for *D* ſay 60480.

9)48(8
5)45(9
5)40(8
5)30(7

900::12

D, 60480. *T*, 12. $\frac{25}{14}$, $\frac{B}{\alpha}$ *ſſ*

And $\frac{25}{14}$. 12::12. 80$\frac{16}{24}$ for *C*.

24. Secondly, if it be demanded whether it may not be made to go 150 hours, with a convenient train ſay *C*. *T*.:: *H*. *ſſ* that is in numbers 150. 12.::12. $\frac{144}{150}$ $\frac{24}{25}$ $\frac{B}{\alpha}$ and 150.:12::60480.

4838 *D* which train will be fit enough if the piece be big, but it is too ſlow for a ſmall Watch.

III.

Of effecting particular motions required.

25. THe number of a motion is the number of the turns of the wheel (*A*) or pinion (*a*) which are gone in one revolution of that motion, or else it is the proportion of that motion to one turn of the wheel, $L = \beta A = H$.

26. A motion to shew the days of the month; because the greatest number of days in any month is 31, and in one day *B* goes about twice the number of a motion shewing the day of the month, shall be $\frac{62}{1} \times \frac{B}{a} A$ or $\frac{62}{4} \times \frac{4}{1} \times \frac{B}{a} A$ or $\frac{62}{4} \times \frac{4 \times 10}{10} \times \frac{B}{a} A$ (for (*a*) pinion 1 moveth not) but $\frac{B}{a} A$ are all ready in the Movement, therefore $\frac{62}{4} \times \frac{40}{10} B$ in wheels shall express the motion; that is on the wheel *B* fix concentrick a pinion

pinion 10 leading a wheel of 40, which again by a pinion of 4 shall carry about a ring of 62, divided on the upper side into 31 days.

IV.

A Motion to shew the age of the Moon.

27. BEcause the number of the Moons revolutions is days $29\frac{1}{2}$ or $\frac{59}{2}$ and in one day B goes twice about, the number of a Motion shewing the age of the Moon, shall be $\frac{59}{1} \times \frac{B}{\alpha}A$, or $\frac{59}{4} \times \frac{4}{1} \times \frac{B}{\alpha}A$, or $\frac{59}{4} \times \frac{4 \times 10}{10} \times \frac{B}{\alpha}A$ (for a pinion 1 moveth not) but $\frac{B}{\alpha}A$ are already in the Movement, therefore $\frac{59}{4} \times \frac{40}{10}B$ in wheels shall expres the motion this upon the wheel B fix concentrick a pinion of 10 leading a wheel of 40, which again by a pinion

pinion of 4 ſhall carry about a ring of 59 divided into days $29\frac{1}{2}$.

V.

A Motion to ſhew the day of the year, or the degree of the Sun in the Ecliptick, or the time of the Suns riſing or ſetting, &c.

28. BEcauſe the number of days of a common year is 365, and in one day *B* goeth about twice, the number of a Motion ſhewing the day of the year ſhall be, $\frac{73}{1}\frac{0}{a} \times \frac{B}{a}A$, or $\frac{73}{1} \times \frac{10}{1} \times \frac{B}{a}A$, or $\frac{73}{4} \times \frac{4}{1} \times \frac{10}{5} \times \frac{5}{1} \times \frac{B}{a}A$, or $\frac{73}{4} \times \frac{10 \times 5}{5} \times \frac{4 \times 5}{4} \times \frac{B}{a}A$ (for a pinion 1 moveth not) but $\frac{B}{a}A$ already in the Movement, therefore $\frac{73}{4} \times \frac{50}{5} \times \frac{20}{4}B$ in wheels, ſhall expreſs the motion; that is upon the wheel *B* fix

fix concentrick a pinion of 4, leading a wheel of 20, which again by a pinion of 5, leadeth a wheel of 50, which thirdly by a pinion of 4, ſhall carry about a wheel of 73, divided on the upper ſide into the 12 months, and their days, or into the 12 ſigns, and their degrees, or into the hours and minutes, of the Suns riſing or ſetting, agreeable to the days of the year, in that Altitude of the Pole, for which you would have the Watch to ſerve.

VI.

To ſhew the hour of full tide at any Port.

29. LEarn in what point the Moon makes full Sea at that place, (as at *London*-Bridge on N. E. and S. W.) convert that point into hours, allow-

allowing for every point N, or S. loſt 45′ of an hour, ſet the hour ſo found gainſt 12 a clock, and beginning at that hour divide a ring in the Dial-plate, cloſe to the Moons ring, into 24 hours, that way the Moons ring moveth; ſo ſhall the day of conjunction or new Moon, with a little ſtud, ſhew the hour of full tide in that part or place every day.

FINIS.